



The non-linear relationship between muscle mass and BMI calls into question the use of BMI as a major criterion for eligibility for bariatric surgery

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Type 2 diabetes mellitus (T2DM) is a growing health problem worldwide, largely because of the high burden of increasing obesity rates [1–3]. In comparison with intensive medical therapy, Roux-en-Y gastric bypass (RYGB) surgery is a particularly effective intervention for T2DM, with about 60% of obese individuals achieving T2DM remission (DR) and sustained weight loss [4,5]. Several predictive factors for DR have been identified, including age, disease duration, glycemic control, and insulin usage [6,7]. However, the predictive performance of existing methods is modest, especially for patients in the lower BMI range ($<30 \text{ kg/m}^2$) who show considerably poorer remission rates (range, 30%–40%) [8]. In addition, one-third of patients who underwent RYGB showed relapse within 5 years of initial remission [4]. Thus, novel DR-related factors are required in order to optimize preoperative evaluation and postoperative management. Indeed, the use of bariatric surgery worldwide is largely governed by a 1991 National Institutes of Health consensus statement that advocated BMI-based operative criteria [9], even though no direct evidence has been obtained to support the ability of BMI to predict DR after surgery [10,11]. One important but underexplored methodological limitation of this approach is that BMI does not discriminate between fat mass and fat-free mass (FFM). Skeletal muscle is the major component of FFM [12] and plays a critical role in whole-body glucose homeostasis [13].

A very recent study by Li et al. published in *Diabetes Care* [14] has revealed the potential relevance of muscle mass assessed by magnetic resonance imaging (MRI) or a predictive equation on BMI limitations in predicting DR after RYGB. It is concluded that a two-phase association exists between muscle mass and BMI and baseline muscle mass or estimated fat-free mass index (eFFMI) are associated with short- and long-term DR after RYGB.

Previous studies had reported that individuals with higher BMIs have a larger skeletal muscle mass and fat mass, and the relationship between BMI and body component was thought to show a positive correlation [15]. In this study, the authors firstly provided compelling new evidence

for the limitations of BMI in assessing body composition, with the muscle mass showing a significant threshold effect with increasing body weight (BMI cut-off = 31.88 for males and 32.66 for females). Similarly, at the inflection point (BMI = 33.71 for males and 33.91 for females), the increment in visceral fat changed despite not being statistically significant ($P = 0.12$) in males and being significant in females ($P = 0.022$). In contrast, subcutaneous fat did not show a breakpoint, which may be attributed to its larger capacity limit. These results indicated that a single BMI value cannot adequately reflect the dynamics of body composition, especially muscle mass. Next, in the longitudinal study for DR with a 5-year follow-up RYGB surgical cohort, psoas cross-sectional area and eFFMI were strong predictors for 1- and 5-year DR after RYGB surgery in Chinese T2DM patients, but BMI did not show such predictive ability. The presence of more muscle mass before surgery indicates a greater possibility of achieving complete DR after surgery.

In conclusion, the non-linear relationship between muscle mass and BMI may explain why BMI cannot adequately predict DR after surgery. The difference in DR rates between the high-BMI ($>30 \text{ kg/m}^2$) and low-BMI populations reported in previous studies may be attributed to the differences in muscle mass between the two groups. This study (along with other published studies) call into question the rationale in using BMI as a criterion for eligibility for bariatric surgery. Predicted FFMI may be a simple parameter superior to BMI to be included in clinical guidelines for preoperative evaluation of bariatric surgery in the future. The fact that the study participants originated from a single ethnic group may in part limit the immediate generalizability of the results, at least until these are validated in other populations as well. Nevertheless, the findings are novel and offer valuable insight into potentially useful prognostic markers for successful diabetes remission in patients with obesity.

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Declaration of competing interest

None.

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